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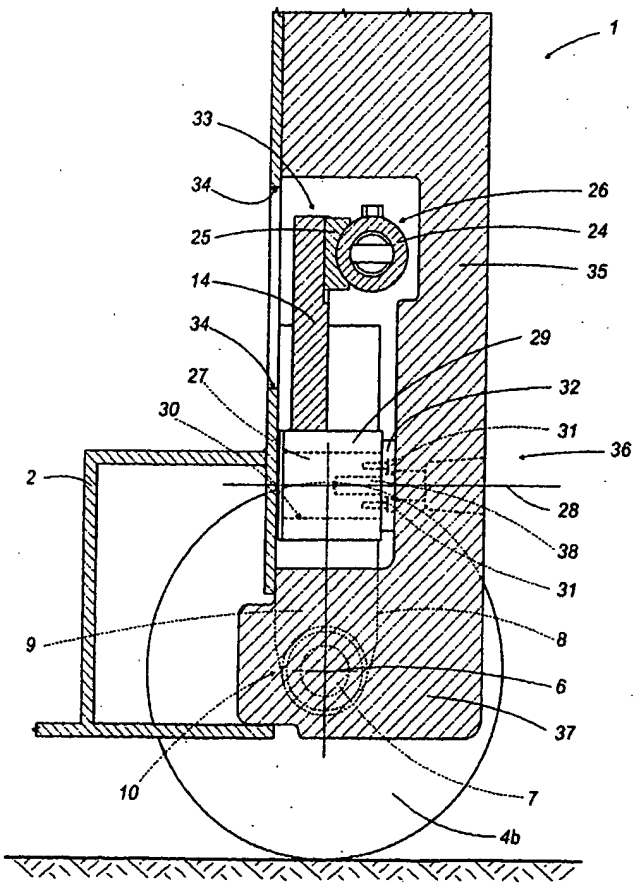
(54) Title: A FORKLIFT TRUCK WITH REDUCED TURNING RADIUS



(57) Abstract: A forklift truck with reduced turning radius is equipped with: a frame (2); two front drive wheels (3a, 3b) that turn about a common axis of rotation (A) transversal to a longitudinal central plane (M) of the forklift truck (1) itself; a rear axle (14) supporting two back wheel mounting forks (10) which rotate about respective second axes (12) substantially parallel to the central plane (M) and mounting in turn two steerable back wheels (4a, 4b); a steering device (26) designed to coordinate the rotation of the mounting forks (10) about the respective second axes (12) in such a way that the centre of rotation (C) of the forklift truck (1) with the steering at full lock is positioned at the point where the first axis (A) intersects the central plane (M); and a rear counterweight (35). The axle (14), the mounting forks (10) and the steering device (26) form a unit (33) which can be pre-assembled and which is supported directly by a back end (36) of the frame (2), which also directly supports the counterweight (35) in a position in which the unit (33) is located between the back end (36) and the counterweight (35) itself. The frame (2) has a rear opening (34) providing access to the steering device (26).

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Description

A forklift truck with reduced turning radius

Technical Field

The present invention relates to a forklift truck with reduced turning radius.

In particular, the invention relates to a four-wheeled forklift truck with relatively reduced minimum turning radius.

Background Art

Conventional forklift trucks comprise a three- or four-wheeled vehicle which may be electrically powered or driven by an internal combustion engine, two horizontal, power-driven forks which extend from the front of the vehicle and are used to lift and lower loads of various kinds, and a rear counterweight to counterbalance the front load.

These forklift trucks, irrespective of their lifting capacities, come in different designs and have distinct characteristics depending on the number of wheels and on whether they have front or back wheel drive.

In forklift trucks with three wheels, two of the three wheels are mounted at the front on a single axis of rotation, while the third wheel is mounted at the back in a longitudinal plane through the centre of the vehicle. Steering is always applied to the back wheel while vehicle drive may be front or back wheel.

In lift trucks where the back wheel is not only the steerable wheel but also the drive wheel, the two front wheels are free to turn about their axes and their direction and speed depend on the steer angle of the back wheel. When the back wheel is at full steering lock, that is to say, turned by 90 degrees, the centre of rotation of the vehicle is located at the point where the common axis of the front wheels intersects the longitudinal central plane of the vehicle. This means the turning radius is relatively small, with obvious advantages in terms of manoeuvrability in confined spaces.

In a lift truck of this kind, the transmission of torque to the ground depends on the vertical load acting on the back wheel, which is the drive wheel. When the truck is carrying a load on the forks, which are at the front, the total vertical load on the back wheel is reduced, thus reducing the grip of the back wheel. The more slippery the ground (as when it is wet, for example) the more this problem is felt.

Instead, if the back wheel is only a steerable wheel and drive is at the front wheels, two different cases can be distinguished: in one case, the front wheels are equipped with a differential; in the other, the front wheels are independently driven.

In the first case, as the back wheel steer angle gets larger, the inside front wheel tends to slow down since it is forced to cover a path whose curvature is smaller than that of the path covered by the outside front wheel. When the maximum steer angle is reached, the inside front wheel does not revolve at all.

At the same time, the vehicle's centre of rotation, which lies on the common axis of the front wheels, can vary from an infinitely distant lateral position, when the front wheels are straight, to a limit position corresponding to the point where the inside front wheel touches the ground when the front wheels are at full steering lock.

It follows that in this case, the minimum turning radius is relatively large.

In the second case, the front wheels are usually driven by two electrical motors. The speed and direction of the wheels are electronically controlled by a control unit in accordance with the steer angle of the back wheel. Thus, when the back wheel is at full steering lock, the control unit causes the inside drive wheel to revolve at the same speed as the outside drive wheel but in the opposite direction so as to prevent the wheels from slipping and sliding. By so doing, the control unit advantageously enables the vehicle to turn about a point where the common axis of the front wheels intersects the longitudinal central plane of the vehicle. This provides the same manoeuvrability as the back wheel drive

truck described above but avoids the problem of reduced grip when heavy loads are being carried.

A three-wheeled truck of this kind, despite its relatively reduced turning radius and good ground grip, is relatively unstable compared to a four-wheeled truck. As taught by prior art, the vertical projection of the truck's centre of gravity must fall within an area which, in the case of this type of truck, is delimited by the triangle defined by the three wheels, otherwise the truck will tip over. Clearly, such an area is smaller than the corresponding rectangular or trapezoidal area of a four-wheeled truck.

In conventional four-wheeled lift trucks, drive is typically on the front wheels, while steering is applied to the back wheels.

The rotation of each of the two back wheels is obviously coordinated with the rotation of the other back wheel in such a way as to prevent the wheels from slipping and sliding.

As in the case of three-wheel configurations, the front wheels may be driven through a differential or independently of each other as described above.

In the case of separate front wheel drive, the prior art describes a steering mechanism which, when at full lock, advantageously positions the vehicle's centre of rotation to the point where the common axis of the front wheels intersects the longitudinal central plane of the truck. This confers the same manoeuvrability as three-wheeled trucks.

The back end of a forklift truck of this type, described by the prior art, is quite complex and this not only complicates truck assembly procedures but also makes maintenance of the steering mechanism more difficult.

In particular, these forklift trucks have a counterweight-rear axle-steering mechanism assembly where the positions of the parts of the assembly relative to each other and of the assembly itself relative to the frame are such as to hamper assembly and maintenance operations.

Disclosure of the Invention

The present invention has for an object to provide an improved forklift truck.

Accordingly, the invention provides a forklift truck with reduced turning radius comprising: a frame; two front drive wheels mounted on said frame in such a way that they rotate about a first common axis of rotation transversal to a longitudinal central plane of the truck; a rear axle; two back wheel mounting forks supported by the axle in such a way that they rotate about respective second axes which are substantially parallel to the central plane; two steerable back wheels supported by the mounting forks; steering means designed to coordinate the rotation of the mounting forks about their respective second axes in such a way that the centre of rotation of the forklift truck with the steering at full lock is positioned at the point where the first axis intersects the central plane; a rear counterweight; the forklift truck being characterised in that the axle, the mounting forks and the steering means form a unit which can be pre-assembled and which is supported directly by a back end of the frame; said back end also directly supporting the counterweight in a position such that the pre-assembled unit is located between the back end and the counterweight.

The invention will now be described with reference to the accompanying drawings which illustrate a preferred embodiment of it purely by way of example and in which:

Figure 1 is a schematic plan view of the forklift truck with reduced turning radius according to the present invention, shown with the steering at full lock;

Figure 2 is a schematic plan view of the forklift truck according to the present invention in condition in which it is travelling forward in a straight line;

Figure 3 is a rear view, with some parts in cross section and some parts cut away for clarity, of an embodiment of the forklift truck according to the present invention;

Figure 4 is a plan view, with some parts in cross section and some parts cut away for clarity, of the back end of the forklift truck illustrated in Figure 3;

Figure 5 is an enlargement of Figure 4, with a dashed line showing also the back end of the truck when the steering is at full lock;

Figure 6 is a side sectional view, through line VI-VI and with some parts cut away for clarity, of the structure illustrated in Figure 4;

Figure 7 is a another rear view, with some parts in cross section and some parts cut away for clarity, of an embodiment of the forklift truck according to the present invention; and

Figure 8 is a cross section, through line VIII-VIII and with some parts cut away for clarity, of the forklift truck illustrated in Figure 7.

With reference to the accompanying drawings, the numeral 1 denotes in its entirety a four-wheeled forklift truck with reduced turning radius.

The forklift truck 1 comprises a frame 2, two front drive wheels 3a and 3b and two back steerable wheels 4a and 4b, and two horizontal front forks (of known type and therefore not illustrated) which are power-driven (in known manner and therefore not illustrated) in such a way that they can lift and lower loads of various kinds (not illustrated).

The front wheels 3a and 3b are driven independently of each other (in known manner) by two respective transmission motors 41 and 42, and are mounted on the frame 2 in such a way that they rotate about a first common fixed axis of rotation A transversal to a longitudinal central plane M of the truck 1.

The hub 5 of each back wheel 4a, 4b has a substantially horizontal axis of rotation 6 and is rotatably supported by a hub mounting 7, which is squarely fitted to a lower end 8 of a branch 9 of a corresponding back wheel mounting fork 10.

The branch 9 is positioned so that it faces the inner surface of the hub 5 and constitutes a lower portion of the wheel mounting fork 10, which is made in a single part and which, above the branch 9 itself, has a central portion consisting of a substantially cylindrical body 11.

The body 11 has a central axis of rotation 12, which is aligned with the inner surface of the hub 5, substantially

parallel to the plane M, and is rotatably mounted on a lateral end 13 of a rear axle 14, which is in turn mounted on the frame 2 transversely to the plane M and extends between the two back wheels 4a and 4b over the two wheels 4a, 4b themselves. Looking in more detail, the body 11 is mounted on the axle 14 on corresponding bearings 15. The latter are positioned inside a joint 16 that is relatively long in the direction of the axis 12 so as to confer on the body 11 relatively high resistance to the shocks transmitted by the branch 9.

Above the body 11, the wheel mounting fork 10 also has an upper portion consisting of a pin 17 which actuates the mounting fork 10 itself.

The pin 17 has a grooved profile 18 by which its top end is slotted to a lever 19 for actuating the wheel mounting fork 10.

The lever 19 is pivoted to an end 20 of a curved connecting rod 21 which is shaped like a circular arc and whose opposite end 22 is pivoted to the operating end 23 of a hydraulic cylinder 24 (of known type) for steering the wheels 4a and 4b.

As shown in Figures 3 and 6, the steering cylinder 24 is rigidly attached to an upper end portion 25 of the axle 14.

The specially shaped assembly formed by the steering cylinder 24, the connecting rods 21 and the levers 19 constitutes a steering device 26 designed to coordinate the angles of rotation of the back wheel mounting forks 10 about their respective axes 12 in such a way as to prevent the wheels 4a and 4b from slipping or sliding, and to enable the truck 1 to reach a full steering lock configuration in which the centre of rotation C of the truck 1 coincides with the point where the axis A intersects the plane M. Looking in more detail, this configuration, shown in Figure 1 and by the dashed line in Figure 5, corresponds to a rotation of 74 degrees and 30 minutes by the outside back wheel 4a, 4b and of 105 degrees and 30 minutes by the inside back wheel 4a, 4b relative to the configuration shown in Figure 2, where the wheels are straight.

The axle 14 is made from sheet metal parts welded to each other and is pivotally mounted on a rear. circular pin 27 of the frame 2 extending in the longitudinal direction of the truck 1

along a horizontal axis 28. Looking in more detail, the axle 14 has below it a parallelepiped-shaped block 29. In the latter there is a circular through hole 30 by which the pin 27 is connected by means of a plurality of bolts 31 arranged in a ring to a round closing plate 32 placed on the side of the frame 2 opposite the axle 14. The axle 14, the steering device 26, the mounting forks 10 and the wheels 4a and 4b can be pre-assembled to form a unit 33 that is easily fitted en bloc to the frame 2, which, as shown in Figure 6, besides directly supporting said unit 33 through the pin 27, has, above the pin 27 itself, an opening 34 providing access to the steering device 26 when maintenance is required. The truck 1 further comprises a counterweight 35 consisting of a single part which closes the back end 36 of the truck 1. Looking in more detail, with reference to Figure 7, the counterweight 35 extends right across the width of the truck 1 and has a lower portion 37 which extends downwards between the wheels 4a and 4b and which is suitably tapered towards the centre to allow the mounting forks 10 to rotate about the axes 12 under the action of the steering device 26.

The counterweight 35 is supported directly by the frame 2 and is attached to the pin 27 by a bolt 38 located at the centre of the ring of bolts 31. The counterweight 35 is mounted in a position such that the unit 33 is placed between the pin 27 and the counterweight 35 itself. In other terms, in this position, the axle 14 and the steering device 26 are surrounded by the counterweight 35 only on the sides (Figure 8), top and bottom (Figure 6). This makes it possible to fit or remove the counterweight 35 independently of the axle 14 and of the steering device 26, while at the same time allowing access to the steering device 26 through the opening 34 without removing the counterweight 35. As mentioned above, the truck 1 is driven by the front wheels 3a and 3b which are in turn driven independently of each other by two respective transmission motors 41 and 42 controlled electronically in known manner by a control unit 43 which controls both their speed and direction in accordance with the steer angles of the back wheels 4a and 4b. For this purpose, the input of the control unit 43 is connected to a rotary type

potentiometer 39 fitted above one of the two pins 17 (in this particular case, as shown in Figures 1, 3, 5 and 8, above the pin 17 corresponding to the back right-hand wheel 4b), the potentiometer spindle 40 being coaxial and attached to the pin 17 itself. The potentiometer 39 detects the steer angle of one of the wheels 4a or 4b through the connection to the pin 17 and outputs a signal to the control unit 43 which accordingly regulates the speed and direction of rotation of the motors 41 and 42. The potentiometer 39, being of the rotary type, permits accurate detection of the steer angle of the back wheels 4a and 4b and thus precise control of the transmission motors 41 and 42 that drive the front wheels 3a and 3b.

Key

1	FORKLIFT TRUCK
2	FRAME
3	FRONT WHEELS
4	BACK WHEELS
5	HUB
6	HUB AXIS
7	HUB MOUNTING
8	LOWER END OF 9
9	BRANCH OF 10
10	WHEEL MOUNTING FORK
11	CENTRAL PORTION (BODY) OF 10
12	AXIS OF 11
13	LATERAL END OF 14
14	AXLE
15	BEARINGS
16	JOINT
17	PIN OF 10
18	GROOVED PROFILE
19	LEVER FOR ACTUATING WHEEL MOUNTING FORK
20	END OF 21
21	CONNECTING ROD
22	END OF 21
23	END OF 24
24	STEERING CYLINDER
25	UPPER PORTION OF 14
26	STEERING DEVICE
27	FRAME PIN
28	AXIS OF 27
29	LOWER BLOCK OF 14
30	HOLE IN 29
31	BOLTS
32	ROUND PLATE
33	PRE-ASSEMBLED UNIT
34	FRAME OPENING
35	COUNTERWEIGHT
36	BACK END OF 1

	37	LOWER PORTION OF 35
	38	BOLT
	39	POTENTIOMETER
	40	SPINDLE OF 39
5	41,42	TRANSMISSION MOTORS
	43	CONTROL UNIT

Claims

1. A forklift truck with reduced turning radius comprising: a frame (2); two front drive wheels (3a, 3b) mounted on said frame (2) in such a way that they rotate about a first common axis of rotation (A) transversal to a longitudinal central plane (M) of the truck (1); a rear axle (14); two back wheel mounting forks (10) supported by the axle (14) in such a way that they rotate about respective second axes (12) which are substantially parallel to the central plane (M); two steerable back wheels (4a, 4b) each supported by one of the mounting forks (10); steering means (26) designed to coordinate the rotation of the mounting forks (10) about their respective second axes (12) in such a way that the centre of rotation (C) of the forklift truck (1) with the steering at full lock is positioned at the point where the first axis (A) intersects the central plane (M); a rear counterweight (35); the forklift truck (1) being characterised in that the axle (14), the mounting forks (10) and the steering means (26) form a unit (33) which can be pre-assembled and which is supported directly by a back end (36) of the frame (2); said back end (36) also directly supporting the counterweight (35) in a position such that the pre-assembled unit (33) is located between the back end (36) and the counterweight (35).

2. The forklift truck according to claim 1, characterised in that the frame (2) has a rear opening (34) providing access to the steering means (26).

3. The forklift truck according to claim 1 or 2, characterised in that the back end (36) comprises a pin (27) that supports both the pre-assembled unit (33) and the counterweight (35).

4. The forklift truck according to any of the foregoing claims, characterised in that it comprises a back end (36) and in that the counterweight (35) consists of a single part which closes the back end (36).

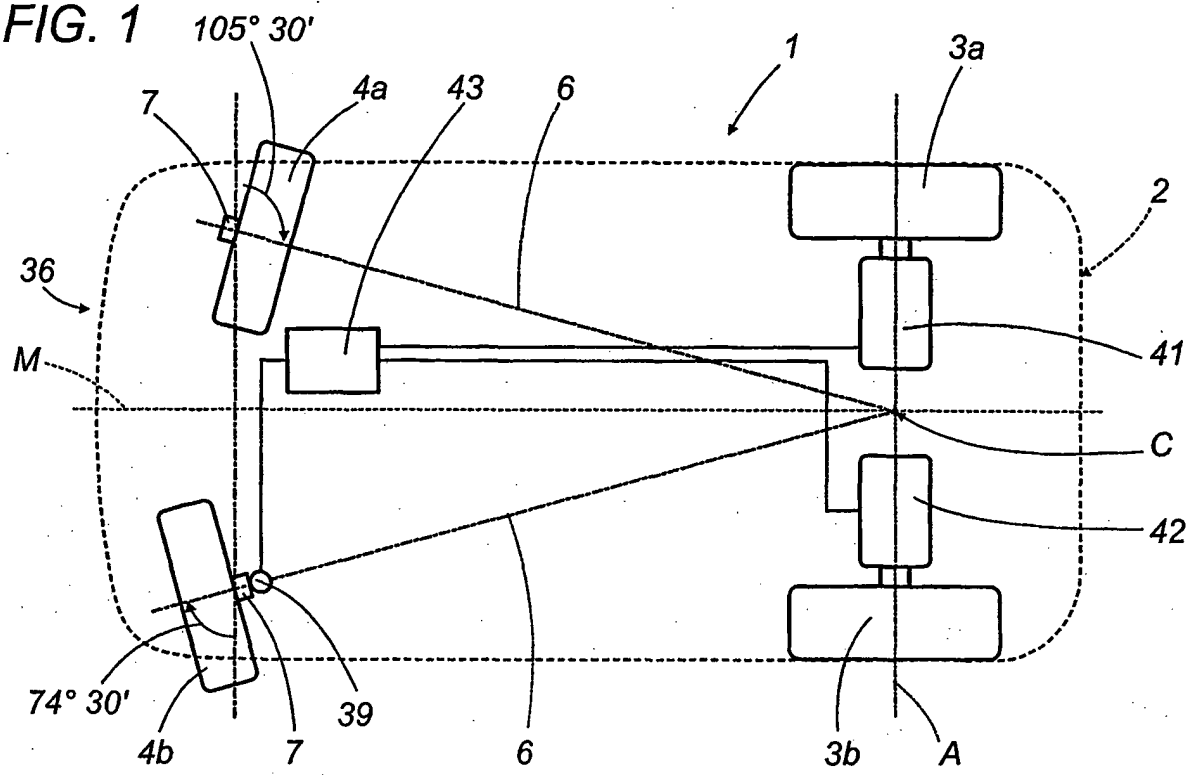
5. The forklift truck according to claim 3 or 4, characterised in that the rear axle (14) comprises sheet metal parts welded to each other and is pivotally mounted on the pin (27).

6. The forklift truck according to any of the foregoing claims, characterised in that the front wheels (3a, 3b) are driven independently of each other by two respective transmission motors (41, 42) controlled electronically by a control unit (43) which controls both their speed and direction of rotation in accordance with the steer angles of the back wheels (4a, 4b).

7. The forklift truck according to claim 6, characterised in that each wheel mounting fork (10) comprises a pin (17) for actuating the mounting fork, and in that the input of the control unit (43) is connected to a rotary potentiometer (39) designed to provide a signal proportional to the steer angle of the back wheels (4a, 4b), the potentiometer (39) having a spindle (40) connected to one of the pins (17) of the back wheels (4a, 4b).

8. The forklift truck according any of the foregoing claims, characterised in that centre of rotation (C) of the truck (1) with steering at full lock is positioned at the point where the central plane (M) intersects the axis (A) thanks to the fact that the front wheels (3a, 3b) can rotate in opposite directions and are driven independently of each other by two respective transmission motors (41, 42) which are electronically controlled by a control unit (43) and characterised also in that the back wheels (4a, 4b) are steered by the steering means (26), which are supported by the pin (27) of the frame (2).

FIG. 1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C
42
74° 30'
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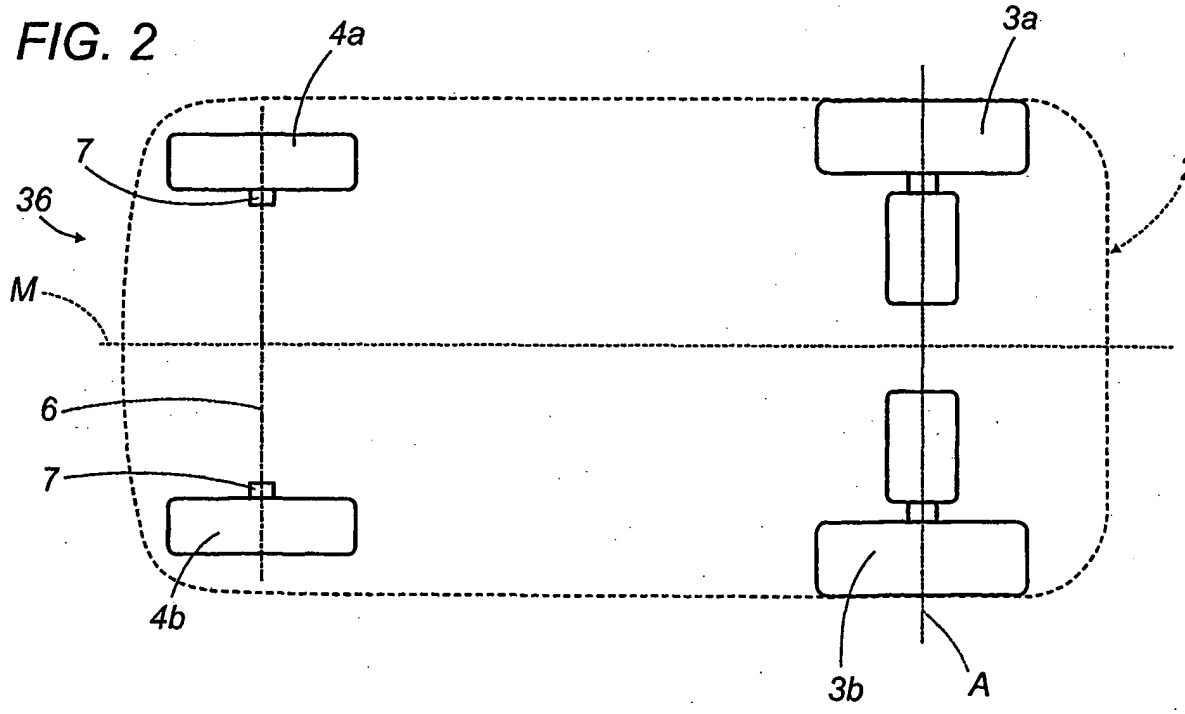
3b
A

FIG. 2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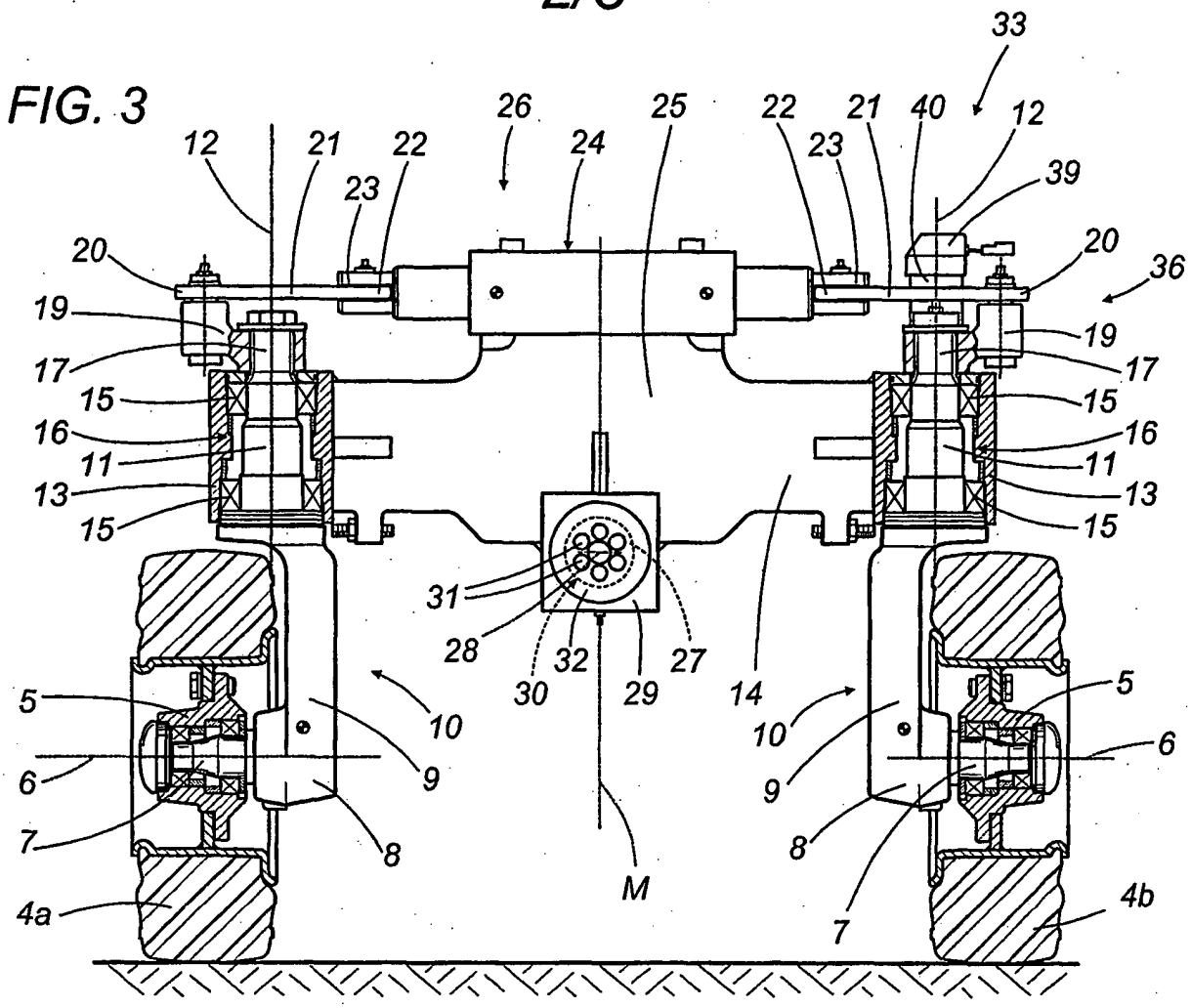
3b
A

FIG. 3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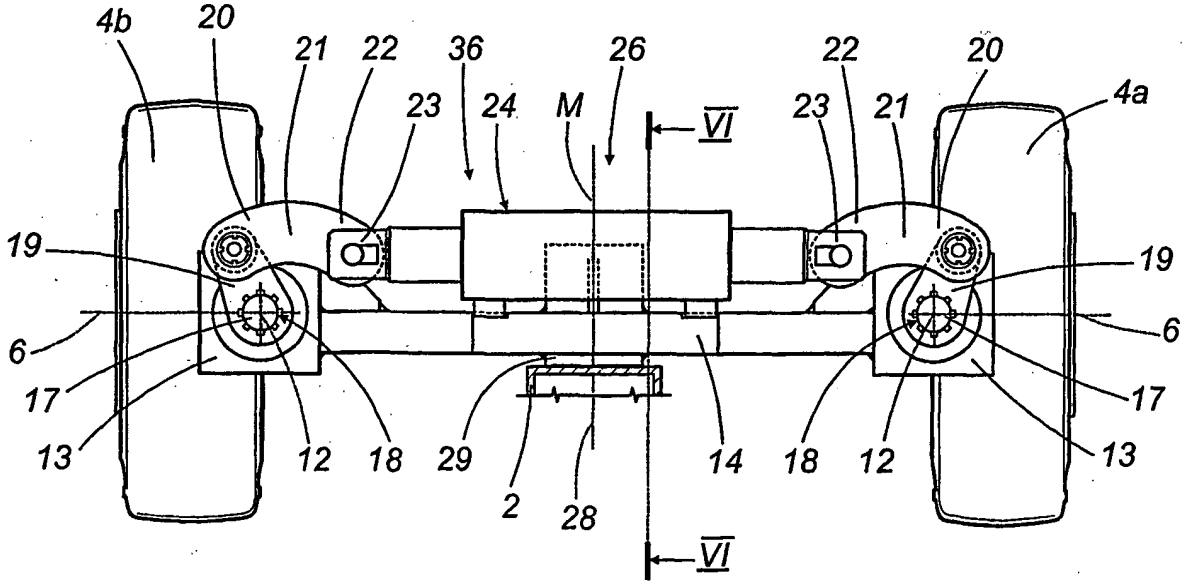
5
6
7
8
M
4a
4b

FIG. 4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VI
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14

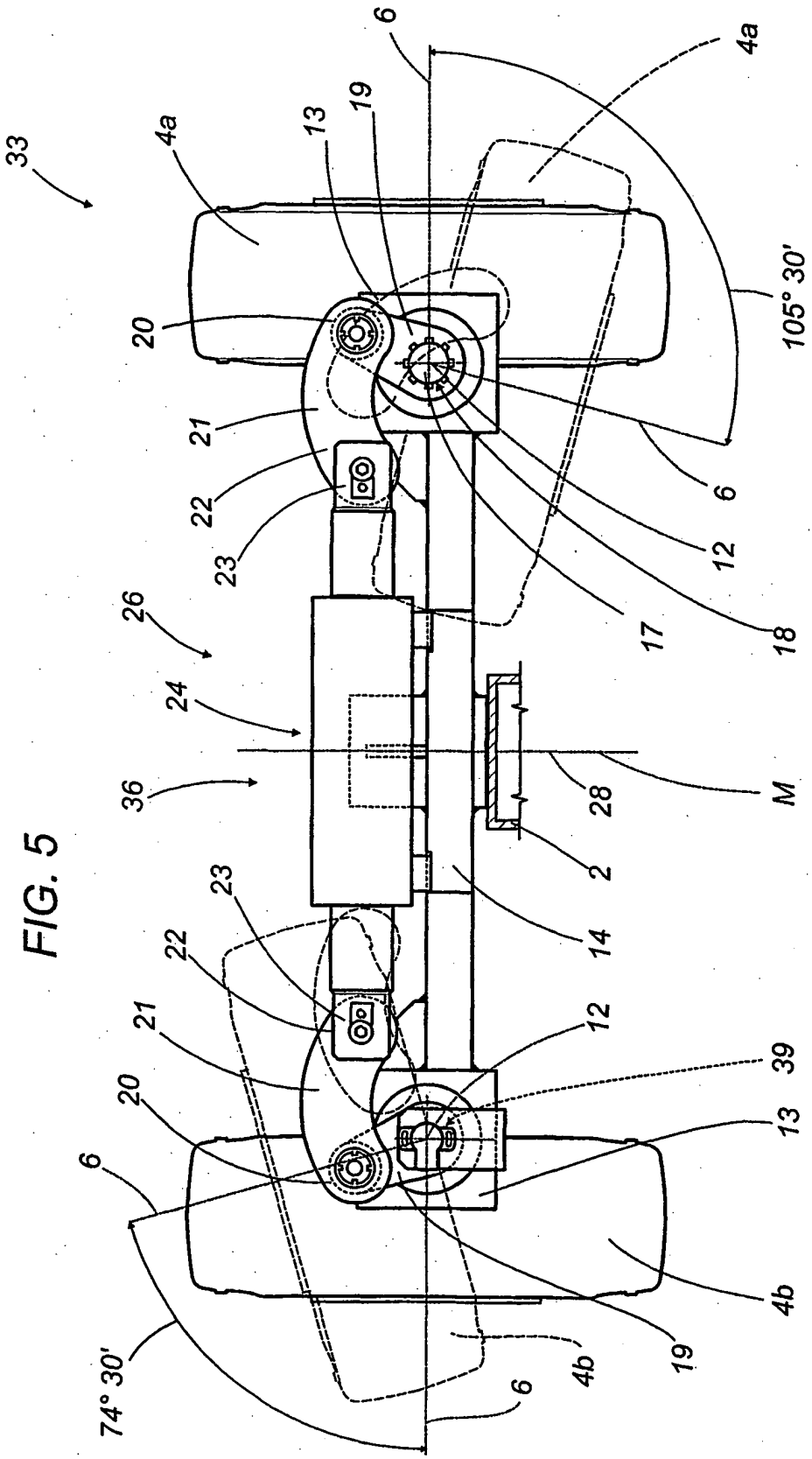
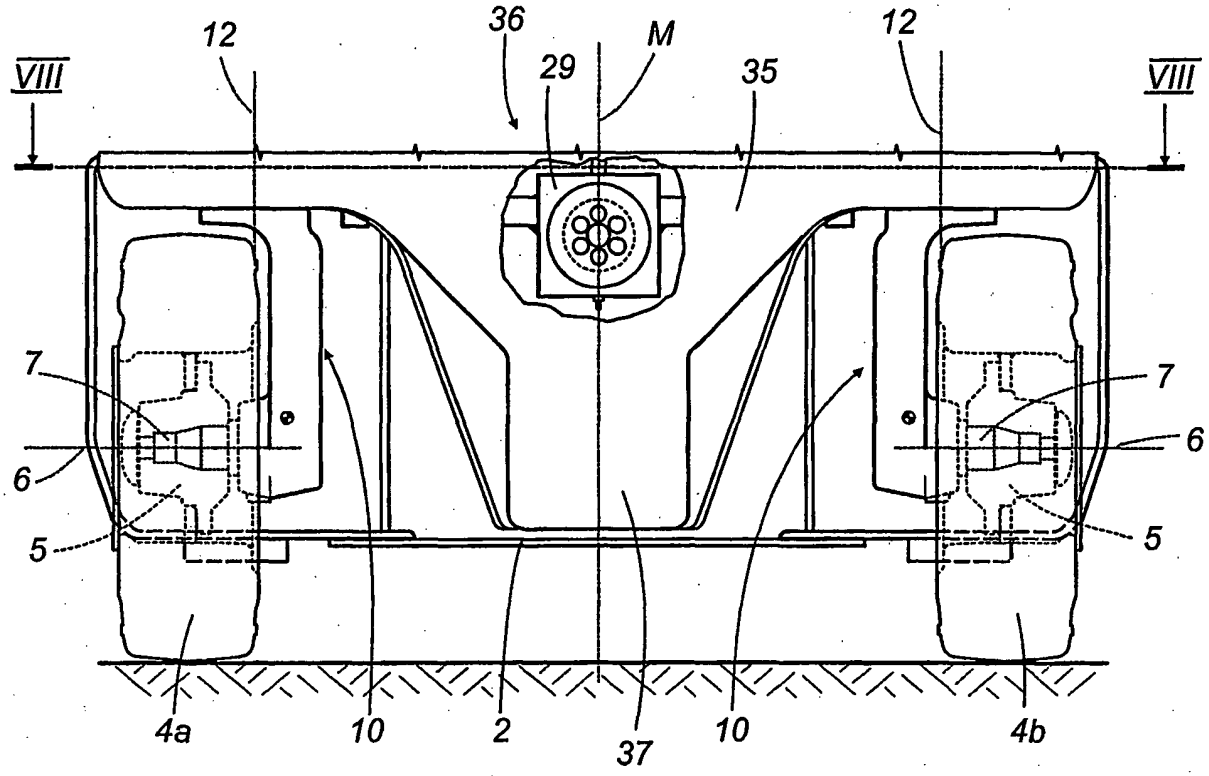


FIG. 5

FIG. 7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4a
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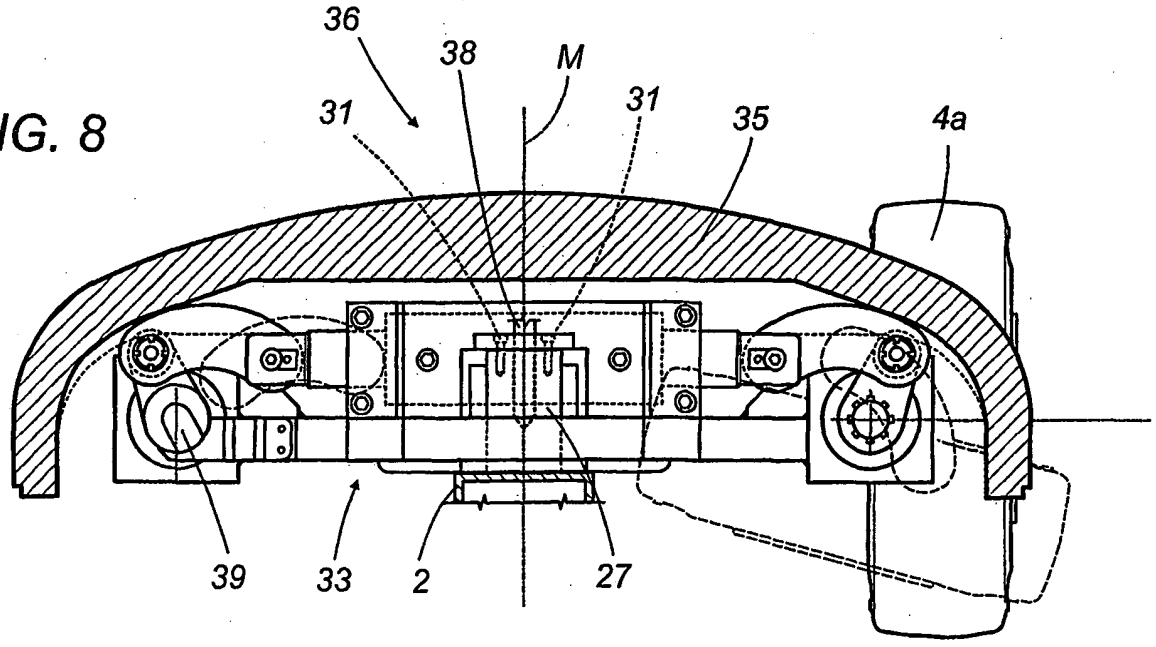
10
4b

FIG. 8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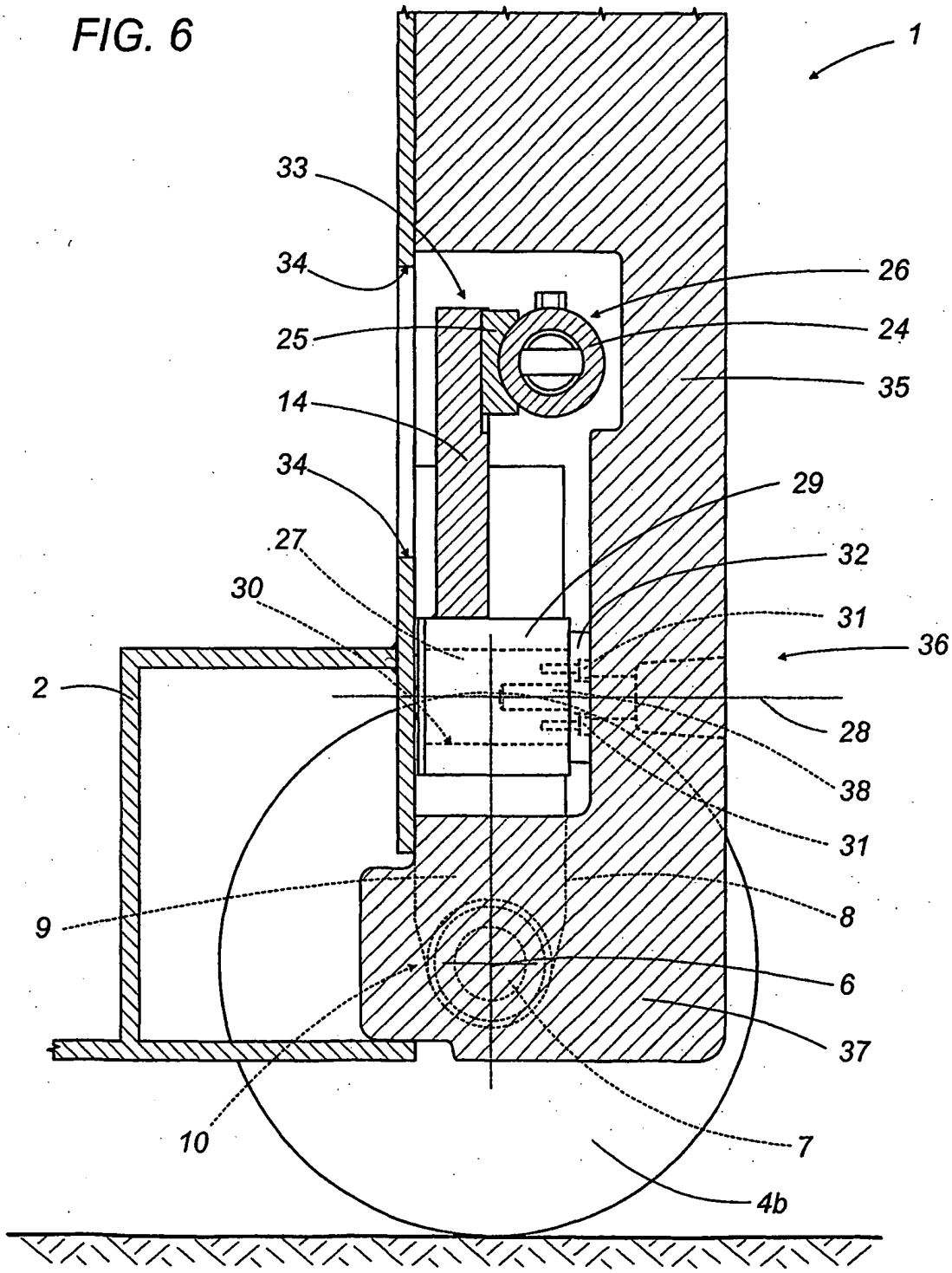
27

FIG. 6



INTERNATIONAL SEARCH REPORT

International Application No
PCT/IB 01/00670

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 B66F9/06 B66F9/075 B62D7/09

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 B66F B62D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal, WPI Data, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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Y	EP 0 741 069 A (BARUZZI ADRIANO ;BUCCHI MAURO (IT); GAETANI ANGELO (IT); BALDINI D) 6 November 1996 (1996-11-06) the whole document	6-8
Y	EP 0 888 951 A (TOYODA AUTOMATIC LOOM WORKS) 7 January 1999 (1999-01-07) abstract	7
A	US 4 342 470 A (MATSUDA MINORU) 3 August 1982 (1982-08-03) the whole document	1

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
1 August 2001	10/08/2001

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Sheppard, B

Form PCT/ISA/210 (second sheet) (July 1992)

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